# 2. Summary of Results

## Accelerated Depletion Case

### Assumptions

Although depletion is incorporated in the Oil and Gas Supply Module (OGSM) of the National Energy Modeling System (NEMS), the Accelerated Depletion Case was developed explicitly to address the issues raised by the six trade associations in their communication with the Department of Energy. The assumptions embodied in the Accelerated Depletion Case differ significantly from those used in the Reference Case and in the *Annual Energy Outlook 2000* (*AEO2000*). The assumptions provided by the Office of Fossil Energy, which were developed in consultation with representatives of the six trade groups, are summarized below:

- **New field discoveries are assumed to be smaller.** As specified by the Office of Fossil Energy, the size of new discoveries was reduced by one-third from the size assumed in the Reference Case, to represent smaller fields being brought into development in the future. Each newly discovered field adds not only proved reserves but also a much larger volume of inferred reserves. Proved reserves are reserves that can be certified using the original discovery wells; inferred reserves are those hydrocarbons that require additional drilling (developmental and other exploratory) before they are termed proved. The bulk of reserve additions in any year comes from inferred reserves. Because the new fields are assumed to be smaller in the Accelerated Depletion Case than in the Reference Case, fewer additions are made to inferred reserves. Overall future drilling in the Accelerated Depletion Case adds less to proved reserves, requiring more drilling to achieve a given level of production than in the Reference Case.

- **New reserves are assumed to be used more intensively.** As stated earlier, the underlying mechanism in the OGSM used to determine production is the P/R ratio. In the accelerated case, the P/R ratio for new proved reserve additions is assumed to be one-third higher than in the Reference Case, again as specified by the client. The Accelerated Depletion Case assumes that the smaller fields discovered with the reduced finding rate described above will be used more intensively than fields have been historically. The expected increased intensity of production is reflected in the higher P/R ratios.

- **Individual wells are assumed to reach a higher peak earlier in their development and to decline more quickly, changing expected well profitability.** In the Accelerated Depletion Case, the discounted cash flow algorithm and expected well profitability, which are used to determine future drilling levels, were adjusted by changing the expected production path of the representative well to match the assumptions made above. Initial flow rates were specified by the client to be one-third higher in the Accelerated Depletion Case than they are in the Reference Case, and production was assumed to decline more rapidly after the peak. Overall recovery from the representative well is roughly the same as in the Reference Case. The change in the production profiles captures the assumption that future wells will draw down reserves more intensively in earlier years than they have historically.

### Results

In the Accelerated Depletion Case, the effects of depletion on future production and prices are stronger than in the Reference Case (Table 1). All other things being equal, production in the Accelerated Depletion Case is projected to be lower, because adding proved reserves is more difficult. As a result, total oil and gas production is projected to be lower. This means that the rate at which the total underlying resource is depleted is actually lower in the Accelerated Depletion Case than in the Reference Case. Thus, in this instance, the term "accelerated depletion" refers to the rate of reduction in future production caused by individual field depletion, rather than the overall rate of resource depletion.

Domestic production and prices in the Accelerated Depletion Case differ from those in Reference Case in several ways, as outlined below:

- **Prices for natural gas are higher in the Accelerated Depletion Case, while crude oil prices are roughly the same.**

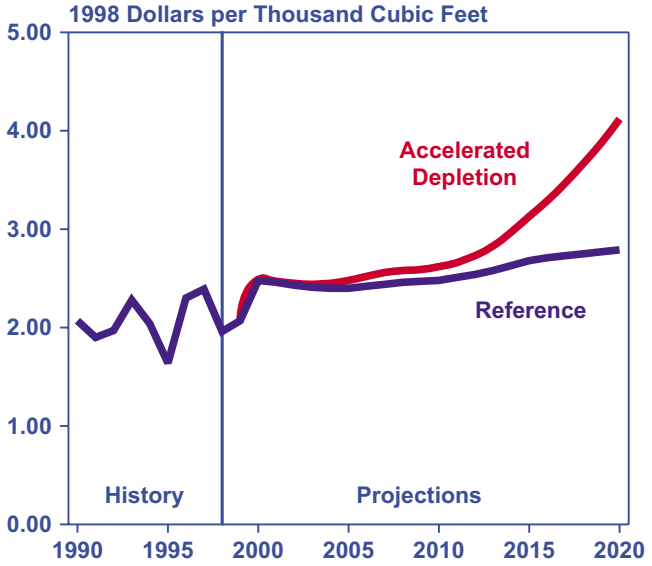
Figure 6 shows how the projected price of natural gas at the wellhead varies from the Reference Case in the Accelerated Depletion Case. The price difference between the two cases grows over time as the cumulative effect of smaller reserve additions reduces production levels in the Accelerated Depletion Case. In 2010, the lower 48 wellhead price of natural gas in the

**Table 1. Projected Lower 48 Crude Oil and Natural Gas Production and Natural Gas Wellhead Prices in the Reference and Accelerated Depletion Cases, 2005-2020**

| Analysis Case | 2005 | 2010 | 2015 | 2020 |
|---|---|---|---|---|
| **Lower 48 Natural Gas Production (Trillion Cubic Feet per Year)** | | | | |
| Reference | 18.9 | 22.2 | 24.7 | 26.0 |
| Accelerated Depletion | 18.7 | 21.8 | 23.4 | 22.5 |
| **Lower 48 Crude Oil Production (Million Barrels per Day)** | | | | |
| Reference | 4.3 | 4.5 | 4.8 | 5.0 |
| Accelerated Depletion | 4.3 | 4.2 | 4.5 | 4.7 |
| **Lower 48 Natural Gas Wellhead Price (1998 Dollars per Thousand Cubic Feet)** | | | | |
| Reference | 2.40 | 2.48 | 2.68 | 2.79 |
| Accelerated Depletion | 2.48 | 2.62 | 3.13 | 4.12 |

Source: Energy Information Administration, Office of Integrated Analysis and Forecasting, National Energy Modeling System runs OGBASE.D051200A and OGDEPL.D051200A.

**Figure 6. Lower 48 Natural Gas Wellhead Prices in the Reference and Accelerated Depletion Cases, 1990-2020**




Source: Energy Information Administration, Office of Integrated Analysis and Forecasting, National Energy Modeling System runs OGBASE.D051200A and OGDEPL.D051200A.

Accelerated Depletion Case is projected to be $2.62 per thousand cubic feet—14 cents higher than in the Reference Case (all prices in 1998 dollars). By 2020, the wellhead price in the Accelerated Depletion Case is projected to be $4.12 per thousand cubic feet—more than double the 1998 price and $1.33 higher than in the Reference Case. Because U.S. oil prices are determined primarily by the world oil price, which generally is unaffected by changes in domestic supply and demand, the projected prices for lower 48 oil at the wellhead are roughly the same in the two cases.

- **Higher natural gas prices lead to lower total energy consumption, lower gas use, and increased use of coal and petroleum.**

Total energy consumption is projected to be about 1 percent lower in the Accelerated Depletion Case than in the Reference Case, a difference of 1.2 quadrillion Btu. Expected total energy use is lower in the Accelerated Depletion Case because of the higher projected natural gas prices. Natural gas consumption in 2020 is roughly 3 quadrillion Btu lower in the Accelerated Depletion Case than in the Reference Case. At the same time, coal use and petroleum use are expected to be 0.7 and 1.0 quadrillion Btu higher, respectively, due to substitution of these fuels for natural gas by consumers faced with higher natural gas prices.[19] The increase in petroleum consumption is made possible by higher projected imports. In the Accelerated Depletion Case, net imports of crude oil and petroleum products increase to 16.9 million barrels per day in 2020, as compared with 15.8 million barrels per day in the Reference Case.

- **Oil and natural gas production is lower in the Accelerated Depletion Case than in the Reference Case, while imports are higher.**

Expected natural gas production in the Accelerated Depletion Case is lower than in the Reference Case (Figure 7), because gas consumption is expected to be lower. The difference is negligible over the first 5 years of the projection but increases over time. In 2015, natural gas production in the lower 48 States in the Accelerated Depletion Case is projected to be 23.4 trillion cubic feet, 1.3 trillion cubic feet lower than in the Reference Case. Gas production increases in the Reference Case between 2015 and 2020 but falls in the Accelerated Depletion Case, and by 2020 it is 3.5 trillion cubic feet, or 13 percent, lower than the Reference Case projection of 26.0 trillion cubic feet.

[19]The projected substitution of coal for natural gas between cases is not just a function of the price in a given year, but also reflects projected capital stocks and relative efficiencies, which are modeled in NEMS. Although coal prices per unit of energy (Btu) produced are projected to be lower than natural gas prices, lower capital and operating costs for natural gas burners make its use economical for electricity generation.

Lower domestic natural gas production in the Accelerated Depletion Case is partially offset by higher imports. While lower 48 production in 2020 is projected to be 3.5 trillion cubic feet lower in the Accelerated Depletion Case than in the Reference Case, natural gas imports are projected to be 640 billion cubic feet higher than in the Reference Case, at 5.5 trillion cubic feet per year. Most of the additional imports are projected to come from Canada; in addition, imports of liquefied natural gas (LNG) are projected to increase by 40 billion cubic feet. In both cases, the United States is projected to be a net exporter to Mexico, with exports exceeding imports from Mexico by 200 billion cubic feet. Increases in imports in response to higher domestic prices for natural gas are constrained in both the Reference and Accelerated Depletion Cases by LNG gasification capacity, expected production levels in Mexico, and limits on pipeline capacity between Canadian gas fields and U.S. markets.

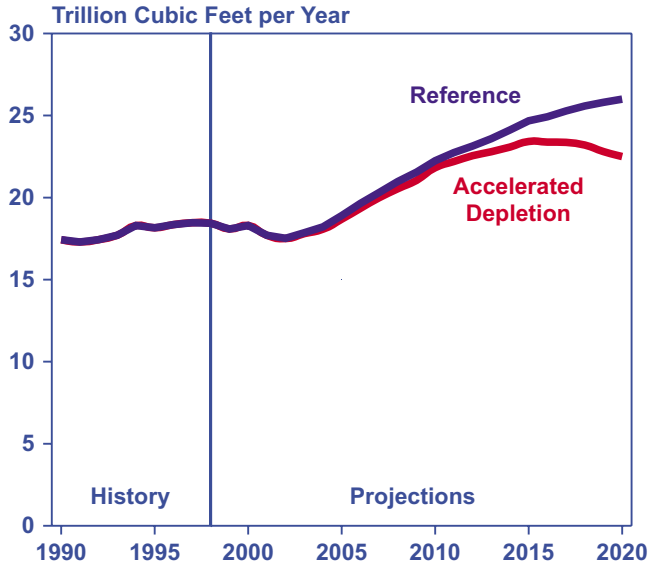
Projected crude oil production in the Accelerated Depletion Case is lower than in the Reference Case throughout most of the projection period. Although oil is more difficult to find in the Accelerated Depletion Case, its price is largely unaffected by the projected decrease in domestic supply. The projected shortfall in production is offset by an increase in imports, which are assumed to be available at the world oil price. Thus, crude oil production in the Accelerated Depletion Case, unlike natural gas production, is not projected to fall as a result of price-related reductions in demand. The assumed high production-to-reserve ratio for new crude oil reserve additions also helps to keep oil production, particularly onshore, from falling off as rapidly as natural gas production. In 2020, lower 48 oil production in the Accelerated Depletion Case is projected to be 4.7 million barrels per day, compared with 5.0 million barrels per day in the Reference Case (Figure 8). The difference is concentrated in offshore production in the Gulf of Mexico. In the Accelerated Depletion Case, smaller fields make some potential projects that were profitable in the Reference Case economically untenable.

- **End-of-year proved reserves drop sharply for natural gas but relatively slowly for crude oil.**

In the Reference Case, end-of-year proved reserves of lower 48 natural gas are projected to be 48 trillion cubic feet higher in 2020 than in 2000, as higher demand requires increased production and therefore more proved reserves. Over the period, reserve additions are projected to outpace production. In contrast, end-of-year natural gas reserves in the Accelerated Depletion Case are projected to increase until 2012 and then decline as the effects of increasingly smaller reserve additions per well accumulate. By 2020, end-of-year reserves in the Accelerated Depletion Case are projected to be 152 trillion cubic feet, 47 trillion cubic feet lower than in the Reference Case and only about 1 trillion cubic feet higher than at the end of 2000.

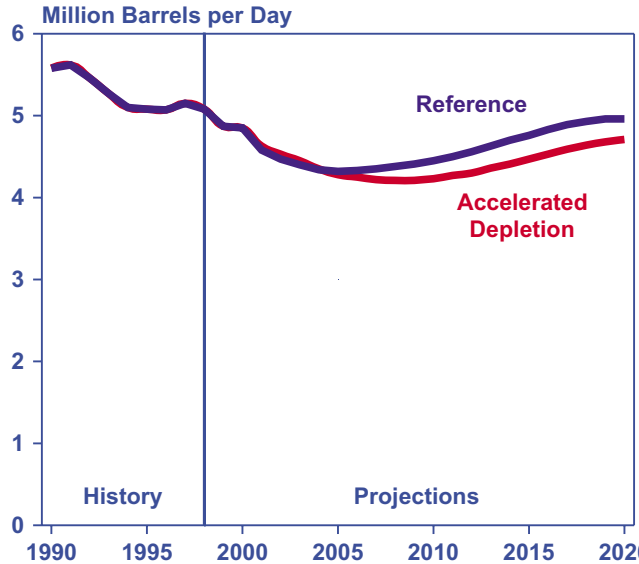
Both the Reference Case and the Accelerated Depletion Case project lower end-of-year crude oil reserves in 2020 than in 2000, as projected production outstrips projected total reserve additions. The Accelerated Depletion Case projects lower 48 reserves of 13.45 billion barrels at the end of 2020, about 0.4 billion barrels (4 percent) less than

**Figure 7. Lower 48 Natural Gas Production in the Reference and Accelerated Depletion Cases, 1990-2020**




Source: Energy Information Administration, Office of Integrated Analysis and Forecasting, National Energy Modeling System runs OGBASE.D051200A and OGDEPL.D051200A.

**Figure 8. Lower 48 Crude Oil Production in the Reference and Accelerated Depletion Cases, 1990-2020**




Source: Energy Information Administration, Office of Integrated Analysis and Forecasting, National Energy Modeling System runs OGBASE.D051200A and OGDEPL.D051200A.

in the Reference Case, as compared with a 24-percent difference in the projections for lower 48 natural gas reserves.The difference in lower 48 crude oil reserves occurs in offshore reserves, with less drilling expected in the Accelerated Depletion Case because there are fewer profitable fields to be found. Lower 48 onshore reserves are projected to be higher in the Accelerated Depletion Case than in the Reference Case, as projected oil drilling is higher.

- **Drilling activity is higher in the Accelerated Depletion Case than in the Reference Case.**

Improvements in well profitability as a result of improved production profiles are expected to lead to more drilling in the Accelerated Depletion Case than in the Reference Case. The total number of wells drilled per year roughly doubles between 2000 and 2020 in the Reference Case, and in the Accelerated Depletion Case the number of wells drilled in 2020 is 6 percent higher than in the Reference Case. Exploratory wells, which make up a relatively small portion of total wells drilled in both cases, are projected to be 16 percent more numerous in the Accelerated Depletion Case than in the Reference Case in 2020, whereas the number of developmental wells is projected to be only about 4 percent higher.

## Sensitivity Analysis

The Accelerated Depletion Case describes how changing the assumptions about depletion alone may influence U.S. oil and natural gas prices and production. To determine the interaction of the accelerated depletion with other major variables in the model, the report specifically considers the effects of changes to the world price of oil, the rate of technological change, and the level of access to areas in the Rocky Mountains where development of natural gas is restricted. The analysis addresses these factors both independently and in combination. The results of these sensitivity cases are presented below.

### Sensitivity of Accelerated Depletion to High Natural Gas Imports

The United States, currently a net importer of natural gas, is expected to continue to rely on imported gas in the future. Accelerated depletion of domestic natural gas resources will cause production to be more difficult in the United States, lowering the amount of natural gas that can be produced at any given price. Although depletion is not limited to the United States, domestic gas fields are considered to be more mature on average than those in Canada, Mexico, or other overseas producers who could supply LNG, suggesting that the effects of accelerated depletion will be felt more strongly by U.S. producers than by the potential suppliers of U.S. imports. Therefore, the higher natural gas prices that domestic consumers would face in the Accelerated Depletion Case could be avoided if additional natural gas imports were available from other countries where the effects of accelerated depletion were less pronounced.

The Accelerated Depletion with High Natural Gas Imports Case is designed to test the sensitivity of the Accelerated Depletion Case results to a change in assumptions that allow import capacity to increase beyond the reference case levels. In the Accelerated Depletion with High Natural Gas Imports Case, several assumptions were changed to show how more imports could influence the projections in the Accelerated Depletion Case.

Three changes were made to the Reference Case assumptions to show how higher projected prices in the Accelerated Depletion Case might increase imports of natural gas, and what effect the increase would have on the rest of the market:

- First, the total capacity for imports from Canada was increased. Increasing Canadian imports are projected in the Reference Case, based on past trends. Imports from Canada roughly doubled from 1990 to 1998, when they accounted for about 14 percent of total supply. Canadian natural gas imports are projected to increase from 1998 to 2020 in both the Reference Case and the Accelerated Depletion Case, but they are constrained by the projected capacity of natural gas pipelines between Canada and the United States. The Accelerated Depletion with High Natural Gas Imports Case relaxes the constraints on potential Canadian imports by increasing pipeline capacity. By 2020, the pipeline capacity to carry natural gas from Canada is projected to be 20 percent higher in the Accelerated Depletion with High Natural Gas Imports Case than in the Reference and Accelerated Depletion Cases. Higher pipeline capacity allows for an increase of 460 billion cubic feet per year in Canadian imports in 2020, 9 percent more than in the Accelerated Depletion Case.
- Second, it was assumed that Mexico would become a net exporter of gas to the United States, rather than a net importer as in the Reference and Accelerated Depletion Cases, with higher prices stimulating an increase in Mexico's production of natural gas for export to the United States. In the Reference and Accelerated Depletion Cases, the United States is projected to export 200 billion cubic feet of gas to the United States in 2020; however, in the Accelerated Depletion with High Natural Gas Imports Case, Mexico is projected to export 90 billion cubic feet per year to the United States in 2020.

- Third, U.S. imports of LNG in the Accelerated Depletion with High Natural Gas Imports Case are projected to increase to 450 billion cubic feet per year in 2020, compared with only 330 billion cubic feet in the Reference Case and 370 billion cubic feet in the Accelerated Depletion Case. Total U.S. imports of natural gas are projected to be 6.36 trillion cubic feet in 2020, compared with 5.52 trillion cubic feet in the Accelerated Depletion Case.

Higher imports lead to lower domestic prices for natural gas than are projected in the Accelerated Depletion Case, as more plentiful supplies allow consumers to buy more gas at lower prices. In the Accelerated Depletion with High Natural Gas Imports Case, the lower 48 wellhead price of natural gas in 2020 is projected to be $3.69 per million cubic feet—$0.90 higher than in the Reference Case but $0.43 lower than in the Accelerated Depletion Case (Table 2). As a result, lower 48 production of natural gas is projected to be lower, at 22.1 trillion cubic feet per year in 2020, than in the Accelerated Depletion Case (22.5 trillion cubic feet in 2020). Because the change in assumptions is limited to imports of natural gas, the projected level of domestic oil production in the High Natural Gas Imports Case is nearly the same as in the Accelerated Depletion Case.

The assumptions for the Accelerated Depletion with High Natural Gas Imports Case do not extend the projected effects of accelerated depletion to either Mexican or Canadian resources. Although those resources are also subject to depletion, development of a methodology to introduce similar accelerated depletion assumptions into the Mexican and Canadian markets is beyond the scope of this analysis.

## Sensitivity of Accelerated Depletion to World Oil Prices

The world price of oil is determined by the international market. Although the U.S. consumes roughly one quarter of all oil consumed internationally, the changes in supply and demand considered in this analysis are small enough to ignore in the context of the world market, and the world price of oil is assumed to be independent of domestic petroleum market changes. World oil prices determine the level of domestic crude oil production, with the difference between domestic supply and demand being made up by imports. Higher oil prices lead to increased drilling for oil, increased domestic production, and lower demand and imports.

The impact of higher oil prices on natural gas prices is limited, because of the limited opportunities for further fuel switching from oil to natural gas. The Reference Case projects that roughly three quarters of all petroleum used in 2020 will be for transportation. The total amount of oil used in transportation is not very sensitive to price, and the NEMS projections show no substitution of natural gas for oil in the transportation sector. When the world oil price assumption is changed, substitution between the two fuels is projected for other sectors of the economy—notably commercial, industrial, and electric generation—but those opportunities are also limited. In total, changes in oil prices have only limited impact on natural gas demand, prices, and production.

This analysis uses the high and low oil price cases developed for *AEO2000* to assess the impact of the world price of oil on production and prices in the Accelerated Depletion Case. The oil price assumptions are designed to represent long-term trends and do not capture short-term

**Table 2. Projected Lower 48 Crude Oil and Natural Gas Production and Natural Gas Wellhead Prices in the Reference, Accelerated Depletion, and Accelerated Depletion with High Natural Gas Imports Cases, 2005-2020**

| Analysis Case | 2005 | 2010 | 2015 | 2020 |
|---|---|---|---|---|
| **Lower 48 Natural Gas Production (Trillion Cubic Feet per Year)** | | | | |
| Reference | 18.9 | 22.2 | 24.7 | 26.0 |
| Accelerated Depletion | 18.7 | 21.8 | 23.4 | 22.5 |
| Accelerated Depletion with High Natural Gas Imports | 18.6 | 21.6 | 23.0 | 22.1 |
| **Lower 48 Crude Oil Production (Million Barrels per Day)** | | | | |
| Reference | 4.3 | 4.5 | 4.8 | 5.0 |
| Accelerated Depletion | 4.3 | 4.2 | 4.5 | 4.7 |
| Accelerated Depletion with High Natural Gas Imports | 4.3 | 4.2 | 4.5 | 4.7 |
| **Lower 48 Natural Gas Wellhead Price (1998 Dollars per Thousand Cubic Feet)** | | | | |
| Reference | 2.40 | 2.48 | 2.68 | 2.79 |
| Accelerated Depletion | 2.48 | 2.62 | 3.13 | 4.12 |
| Accelerated Depletion with High Natural Gas Imports | 2.45 | 2.56 | 2.98 | 3.69 |

Source: Energy Information Administration, Office of Integrated Analysis and Forecasting, National Energy Modeling System runs OGBASE.D051200A, OGDEPL.D051200A, and DEPL2.D071700A.

fluctuations in prices. Through 2001 the forecast was calibrated to more recent projections from EIA's *Short-Term Energy Outlook*,[20] which became available after the completion of *AEO2000*. The world price in 2020 is projected to be $22.04 per barrel (in real 1998 dollars) in the Reference and Accelerated Depletion Cases in this report, $28.04 in the High World Oil Price Case, and $14.90 in the Low World Oil Price Case. In all the cases, the price changes smoothly with each year to reach its 2020 target.

The world oil market has been volatile in recent years. Prices increased sharply during 1999 and the first months of 2000, as the spot price for West Texas Intermediate crude climber from just over $12 a barrel in February 1999 to over $30 a barrel in March 2000. Such volatility is not expected to have much influence on average prices in the long term, as market forces are expected to return prices to a lower level over the next several years.[21]

In the Accelerated Depletion Case, the lower 48 wellhead price for crude oil closely follows the path set by the world price of crude. In 2020, the lower 48 wellhead price is $21.21 per barrel in the Accelerated Depletion Case, compared with $21.27 in the Reference Case. In the High and Low World Oil Price Cases, the lower 48 wellhead price in 2020 is projected to be $27.59 and $13.88 per barrel, respectively (Table 3).

The price difference between the Accelerated Depletion Case and the Accelerated Depletion with High and Low World Oil Price Cases are greater for oil than for natural gas. In the Accelerated Depletion Case, the wellhead price for natural gas is projected to be $4.12 per thousand cubic feet with reference world oil prices, $3.60 per thousand cubic feet with low world oil prices, and $4.40 per thousand cubic feet with high world oil prices (Figure 9). The greatest differences are projected for the later years of the forecast period. Lower 48 wellhead prices for natural gas are higher in the Accelerated Depletion with High World Oil Price Case than in the Accelerated Depletion Case because of higher demand for natural gas in the non-transportation sectors. With lower world oil prices the same sectors substitute oil for natural gas, and the projected gas prices are lower.

Higher wellhead prices lead to higher domestic production of both oil and natural gas (Figure 10). In the Accelerated Depletion with High World Oil Price Case, lower 48 oil production in 2020 is projected to be 5.3 million barrels per day, 13 percent higher than in the Accelerated Depletion Case. With high world oil prices, total U.S. crude oil production is projected to remain higher each year than in the Reference Case. For natural gas, the assumption of accelerated depletion keeps production levels below those in the reference case even when high world oil prices are also assumed (Figure 11). Lower 48 natural gas production in the Accelerated Depletion with High World Oil Price Case is projected to be 23.0 trillion cubic feet per year in 2020, compared with 22.5 trillion cubic feet in the Accelerated Depletion Case and 26.0 trillion cubic feet in the Reference Case.

## Sensitivity of Accelerated Depletion to Rates of Technology Improvement

NEMS incorporates assumptions about the rate of technological change into its projections of future energy use. Technology enters the OGSM in three major ways:

- **Future costs are reduced.** Drilling, lease equipment, and operating costs incorporate the separate impacts

**Table 3. Projected Lower 48 Crude Oil and Natural Gas Production and Natural Gas Wellhead Prices in the Accelerated Depletion and Accelerated Depletion with High and Low World Oil Price Cases, 2005-2020**

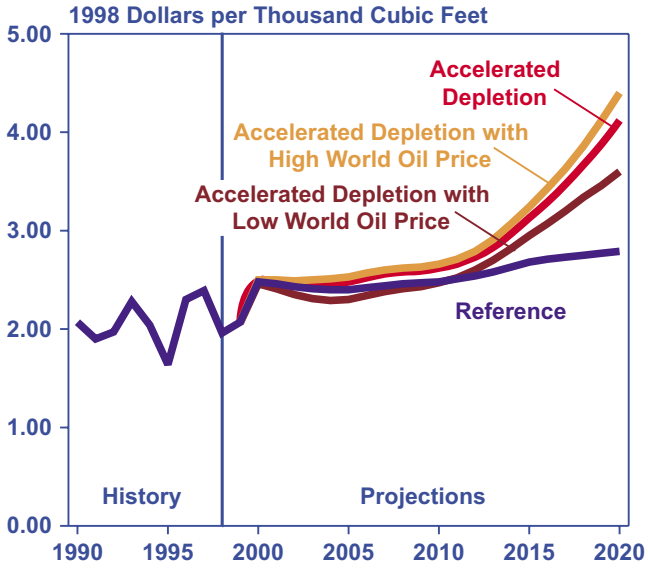
| Analysis Case | 2005 | 2010 | 2015 | 2020 |
|---|---|---|---|---|
| **Lower 48 Natural Gas Production (Trillion Cubic Feet per Year)** | | | | |
| Accelerated Depletion | 18.7 | 21.8 | 23.4 | 22.5 |
| Accelerated Depletion with High World Oil Price | 18.9 | 22.2 | 23.8 | 23.0 |
| Accelerated Depletion with Low World Oil Price | 18.6 | 21.7 | 22.9 | 21.9 |
| **Lower 48 Crude Oil Production (Million Barrels per Day)** | | | | |
| Accelerated Depletion | 4.3 | 4.2 | 4.5 | 4.7 |
| Accelerated Depletion with High World Oil Price | 4.5 | 4.5 | 4.9 | 5.3 |
| Accelerated Depletion with Low World Oil Price | 4.0 | 3.9 | 3.9 | 4.1 |
| **Lower 48 Natural Gas Wellhead Price (1998 Dollars per Thousand Cubic Feet)** | | | | |
| Accelerated Depletion | 2.48 | 2.62 | 3.13 | 4.12 |
| Accelerated Depletion with High World Oil Price | 2.53 | 2.66 | 3.24 | 4.40 |
| Accelerated Depletion with Low World Oil Price | 2.30 | 2.47 | 2.95 | 3.60 |

Source: Energy Information Administration, Office of Integrated Analysis and Forecasting, National Energy Modeling System runs OGDEPL.D051200A, OGHWOP.D051200A, and OGLWOP.D051200A.

[20]Energy Information Administration, *Short-Term Energy Outlook*, DOE/EIA-0202(00/2Q) (Washington, DC, April 2000), www.eia.doe.gov/pub/forecasting/steo/oldsteos/apr00.pdf.

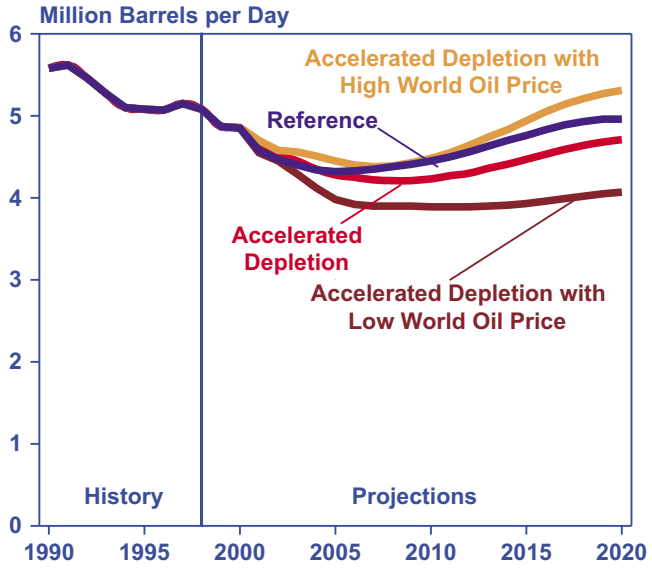
[21]For a detailed discussion of the expected influence of recent high prices on long-term oil markets, see "Oil Market Volatility: The Long-Term Perspective," in Energy Information Administration, *International Energy Outlook 2000*, DOE/EIA-0484(2000) (Washington, DC, March 2000), p. xii.

**Figure 9. Lower 48 Natural Gas Wellhead Prices in the Reference, Accelerated Depletion, and Accelerated Depletion with High and Low World Oil Price Cases, 1990-2020**




Source: Energy Information Administration, Office of Integrated Analysis and Forecasting, National Energy Modeling System runs OGBASE.D051200A, OGDEPL.D051200A, OGHWOP.D051200A, and OGLWOP.D051200A.

**Figure 10. Lower 48 Crude Oil Production in the Reference, Accelerated Depletion, and Accelerated Depletion with High and Low World Oil Price Cases, 1990-2020**



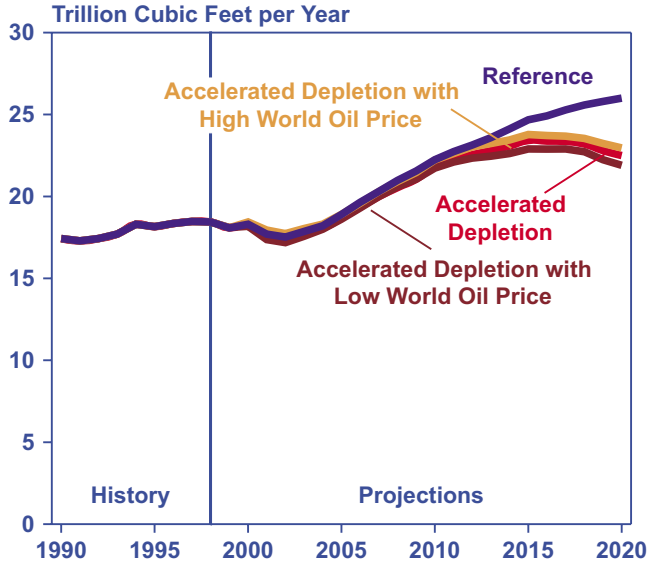

Source: Energy Information Administration, Office of Integrated Analysis and Forecasting, National Energy Modeling System runs OGBASE.D051200A, OGDEPL.D051200A, OGHWOP.D051200A, and OGLWOP.D051200A.

of drilling to greater depths, the level of drilling activity, and technological progress. For drilling costs to decline, technological improvement must offset the upward pressure on costs due to drilling to deeper depths and increased drilling activity. In general, projected future drilling costs decline incrementally with each additional year, along with equipment costs and lease operating costs. This represents the oil and gas industry's continuing innovation in techniques that reduce production costs.

- **Drilling is more accurate.** The success rate for exploratory wells increases, as technology reduces the ratio of dry holes to total drilling activity.
- **Drilling becomes more effective.** The amount of reserve additions per well (or finding rate) captures the impact of technological improvement (as well as the effects of price variations and declining resources). In the absence of technology and price impacts the finding rate declines, reflecting the natural progression of the discovery process from larger, more profitable fields to smaller, less economical ones. Technological improvement helps to offset the natural decline in the finding rate.

The effects of technology on production are modeled differently in each submodule of OGSM, but each module captures the effects of technology on production costs and drilling activity. In the conventional oil and gas module, technology enters as a parameter in the cost equations and finding rate equations. In the unconventional module, which is play-specific, technology

**Figure 11. Lower 48 Natural Gas Production in the Reference, Accelerated Depletion, and Accelerated Depletion with High and Low World Oil Price Cases, 1990-2020**




Source: Energy Information Administration, Office of Integrated Analysis and Forecasting, National Energy Modeling System runs OGBASE.D051200A, OGDEPL.D051200A, OGHWOP.D051200A, and OGLWOP.D051200A.

determines the years in which certain plays may be opened for development, how quickly the best producing locations in a given play can be identified, when certain techniques will become available, and at what rate costs will decline. (A play is defined as a set of oil or gas

accumulations sharing similar geologic, geographic, and temporal properties.)

The focus of this part of the analysis is to consider how changes in assumptions about future technological development change the effects of accelerated depletion on U.S. oil and natural gas prices and production. For oil, the analysis considers only how technological change influences U.S. production. The world oil price is assumed to follow the same path in these sensitivity cases as in the Reference Case.

### Rapid and Slow Technology Cases

As a first approach to assess the effect of varying the rate of technological development on prices and production in the Accelerated Depletion Case, the drilling success rates, finding rates, and changes in costs were adjusted in the conventional modules, with corresponding changes in the unconventional production modules. The assumptions for the Rapid and Slow Technology Cases are similar to those for the *AEO2000* rapid and slow technology cases, with only minor differences (see Appendix E for detailed assumptions). The Accelerated Depletion with Rapid and Slow Technology Growth Cases are designed to highlight the uncertainty around the effects of technological development, but they should not be considered a formal confidence interval.

Faster growth of technology in the Accelerated Depletion with Rapid Technology Growth Case is accompanied by higher projected natural gas production (Table 4 and Figure 12). Natural gas production in 2020 in the Accelerated Depletion with Rapid Technology Case is projected at 28.4 trillion cubic feet, as compared with 22.5 trillion cubic feet in the Accelerated Depletion Case, and is higher in every year of the forecast. Faster improvement in drilling technology is also projected to result in lower wellhead prices (Figure 13). In the Accelerated Depletion with Rapid Technology Case, the price of natural gas is projected to be $2.37 per thousand cubic feet in 2020 (more than 40 cents lower than in the Reference Case), compared with $4.12 per thousand cubic feet in the Accelerated Depletion Case.

Like natural gas production, projected crude oil production in the lower 48 States is higher when rapid technology growth is assumed. Production of more than 5 million barrels per day is projected for 2020 in the Accelerated Depletion with Rapid Technology Case, compared with 4.7 million barrels per day in the Accelerated Depletion Case. With rapid technology growth, oil production is uniformly higher throughout the forecast than it is in the Accelerated Depletion Case or the Reference Case (Figure 14). The wellhead price of crude oil in the lower 48 States changes only slightly, because the world oil price is independent of the technology assumption.

In the Accelerated Depletion with Slow Technology Case, the effects of accelerated depletion on prices and production are exacerbated. By 2020, the wellhead price of natural gas is projected to be an additional 44 cents per thousand cubic feet higher and lower 48 gas production an additional 2.2 thousand cubic feet less than in the Accelerated Depletion Case. Lower 48 oil production in 2020 is also lower by 700,000 barrels per day, or roughly 14 percent, than in the Accelerated Depletion Case.

### Improved and Reduced Productivity Technology Cases

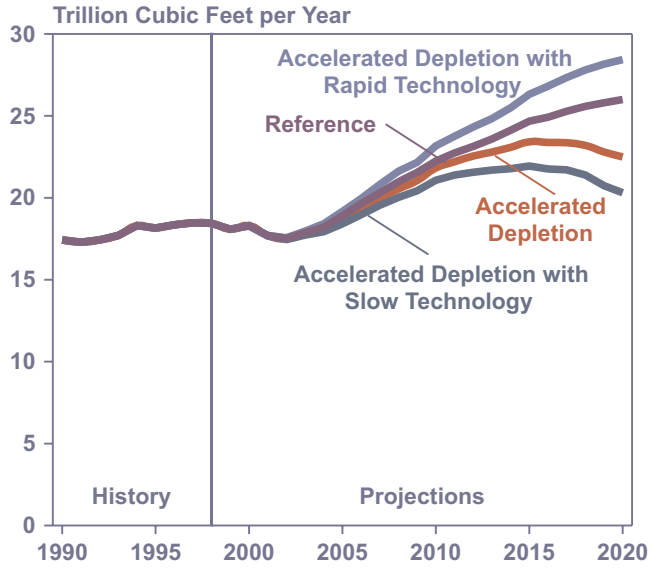
In addition to the Accelerated Depletion with Rapid and Slow Technology Cases, this analysis also considers Accelerated Depletion with Improved and Reduced Productivity Technology Cases, which are subsets of the technology sensitivity cases described above. In these more focused cases, the changes in the assumed rate of

**Table 4. Projected Lower 48 Crude Oil and Natural Gas Production and Natural Gas Wellhead Prices in the Accelerated Depletion and Accelerated Depletion with Rapid and Slow Technology Cases, 2005-2020**

| Analysis Case | 2005 | 2010 | 2015 | 2020 |
|---|---|---|---|---|
| **Lower 48 Natural Gas Production (Trillion Cubic Feet per Year)** | | | | |
| Accelerated Depletion | 18.7 | 21.8 | 23.4 | 22.5 |
| Accelerated Depletion with Rapid Technology Growth | 19.2 | 23.2 | 26.8 | 28.4 |
| Accelerated Depletion with Slow Technology Growth | 18.4 | 21.1 | 21.9 | 20.3 |
| **Lower 48 Crude Oil Production (Million Barrels per Day)** | | | | |
| Accelerated Depletion | 4.3 | 4.2 | 4.5 | 4.7 |
| Accelerated Depletion with Rapid Technology Growth | 4.4 | 4.6 | 5.0 | 5.3 |
| Accelerated Depletion with Slow Technology Growth | 4.1 | 4.0 | 4.0 | 4.0 |
| **Lower 48 Natural Gas Wellhead Price (1998 Dollars per Thousand Cubic Feet)** | | | | |
| Accelerated Depletion | 2.48 | 2.62 | 3.13 | 4.12 |
| Accelerated Depletion with Rapid Technology Growth | 2.31 | 2.30 | 2.32 | 2.37 |
| Accelerated Depletion with Slow Technology Growth | 2.57 | 2.83 | 3.59 | 4.56 |

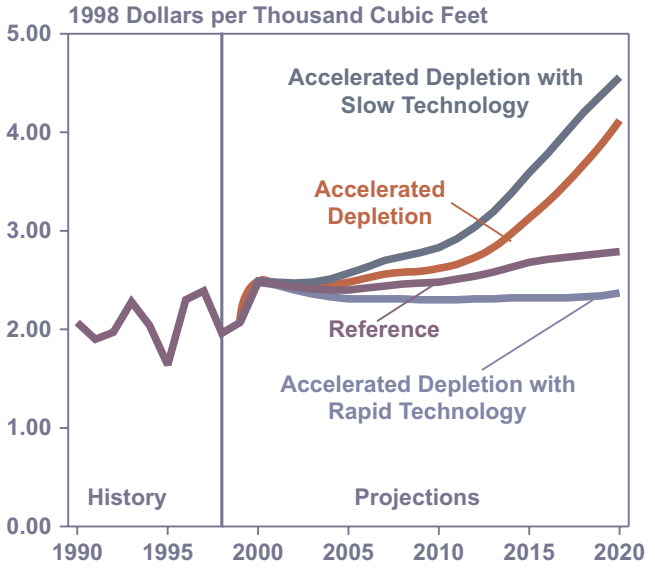
Source: Energy Information Administration, Office of Integrated Analysis and Forecasting, National Energy Modeling System runs OGDEPL.D051200A, OGRTECH.D051200A, and OGSLOW.D051200A.

**Figure 12. Lower 48 Natural Gas Production in the Reference, Accelerated Depletion, and Accelerated Depletion with Rapid and Slow Technology Cases, 1990-2020**




Source: Energy Information Administration, Office of Integrated Analysis and Forecasting, National Energy Modeling System runs OGBASE.D051200A, OGDEPL.D051200A, OGRTECH.D051200A, and OGSLOW. D051200A.

**Figure 13. Lower 48 Natural Gas Wellhead Prices in the Reference, Accelerated Depletion, and Accelerated Depletion with Rapid and Slow Technology Cases, 1990-2020**



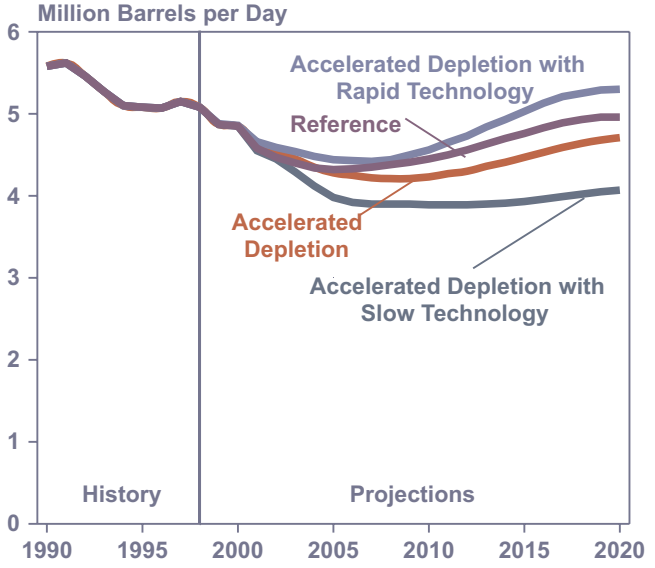

Source: Energy Information Administration, Office of Integrated Analysis and Forecasting, National Energy Modeling System runs OGBASE.D051200A, OGDEPL.D051200A, OGRTECH.D051200A, and OGSLOW. D051200A.

technological progress from the Reference Case are limited to advances in production technology only. In the conventional model, only the finding rate, or the ultimate amount of proved reserves added with each well is adjusted. The other parameters, specifically the effects of technological development on costs and success rates for drilling, are not adjusted in this case, which was designed specifically to capture changes in production technology by itself. In the unconventional natural gas module, the adjustments for the Accelerated Depletion with Improved and Reduced Productivity Technology Cases are limited to performance technology assumptions, and not the assumptions about changes in costs or exploration technology (see Appendix E for specific assumptions).

Relative to the Reference Case, changes in prices and production in the Improved and Reduced Productivity Technology Cases are similar to those in the Accelerated Depletion Case but not as pronounced. Higher production in the Accelerated Depletion with Improved Productivity Technology Case leads to a projected natural gas wellhead price of $2.99 per thousand cubic feet in 2020, compared with $4.12 in the Accelerated Depletion Case (Table 5) and $2.37 in the Accelerated Depletion with Rapid Technology Growth Case (Table 4). Total gas production in 2020 in the Accelerated Depletion with Improved Productivity Technology Case is 3.3 trillion cubic feet higher than in the Accelerated Depletion Case.

Changing the finding rate by itself is enough to bring total natural gas production close to the levels projected

**Figure 14. Lower 48 Crude Oil Production in the Reference, Accelerated Depletion, and Accelerated Depletion with Rapid and Slow Technology Cases, 1990-2020**




Source: Energy Information Administration, Office of Integrated Analysis and Forecasting, National Energy Modeling System runs OGBASE.D051200A, OGDEPL.D051200A, OGRTECH.D051200A, and OGSLOW. D051200A.

in the Reference Case. Lower 48 natural gas production in the Accelerated Depletion with Improved Productivity Technology Case is slightly higher then in the Reference Case through most of the years of the forecast but slows to a level about 1 percent below the Reference

**Table 5. Projected Lower 48 Crude Oil and Natural Gas Production and Natural Gas Wellhead Prices in the Accelerated Depletion and Accelerated Depletion with Improved and Reduced Productivity Technology Cases, 2005-2020**

| Analysis Case | 2005 | 2010 | 2015 | 2020 |
|---|---|---|---|---|
| **Lower 48 Natural Gas Production (Trillion Cubic Feet per Year)** | | | | |
| Accelerated Depletion | 18.7 | 21.8 | 23.4 | 22.5 |
| Accelerated Depletion with Improved Productivity Technology | 19.0 | 22.8 | 25.2 | 25.8 |
| Accelerated Depletion with Reduced Productivity Technology | 18.6 | 21.6 | 22.8 | 21.9 |
| **Lower 48 Crude Oil Production (Million Barrels per Day)** | | | | |
| Accelerated Depletion | 4.3 | 4.2 | 4.5 | 4.7 |
| Accelerated Depletion with Improved Productivity Technology | 4.4 | 4.6 | 5.0 | 5.3 |
| Accelerated Depletion with Reduced Productivity Technology | 4.1 | 4.0 | 4.0 | 4.1 |
| **Lower 48 Natural Gas Wellhead Price (1998 Dollars per Thousand Cubic Feet)** | | | | |
| Accelerated Depletion | 2.48 | 2.62 | 3.13 | 4.12 |
| Accelerated Depletion with Improved Productivity Technology | 2.37 | 2.39 | 2.65 | 2.99 |
| Accelerated Depletion with Reduced Productivity Technology | 2.49 | 2.66 | 3.33 | 4.24 |

Source: Energy Information Administration, Office of Integrated Analysis and Forecasting, National Energy Modeling System runs OGDEPL.D051200A, OGFRHTEC.D051200A, and OGFRLTEC.D051200A.

Case level in 2020. Lower 48 gas prices in the two cases differ by no more than 10 cents per thousand cubic feet until the last two years of the forecast. Oil production is uniformly higher in the Accelerated Depletion with Improved Productivity Technology Case than in the Reference Case, suggesting that the effects of accelerated depletion could be partially offset by improving production technology alone. The rate of technological growth assumed in the improved technology case is a composite of many individual expected improvements. Projecting the specific technologies introduced—and the level of investment that would be required to develop the technologies—is not within the scope of this analysis.

## Sensitivity of Accelerated Depletion to Increased Access to Federal Lands in the Rocky Mountain Region

A large portion of the Nation's natural gas resource base is located on Federal lands (and in Federal waters) where development is restricted or prohibited. These restrictions reduce the accessible resource base and limit industry's ability to exploit known resources.

The Rocky Mountain region is an area of high future potential for natural gas production. Environmental and other constraints currently preclude industry's access to about 45 percent of the resource. The Rocky Mountain resource volumes and access restrictions are consistent with the findings of the recent National Petroleum Council study, which found that 40 percent of the natural gas resource located in the Rockies is either closed to exploration or faces severe restrictions on development.

Efficient development of the resource is further restricted by the complex nature of the reservoirs found in the Rocky Mountain basins. Much of the gas resource is locked in coalbed methane, gas shales, and low permeability/low porosity ("tight") sandstone formations—reservoirs that require special characterization, drilling, completion, and production techniques to become economically feasible to produce.

### *Accelerated Depletion in Rocky Mountain Basins*

In the Accelerated Depletion Case, a "current technology" recoverable unconventional gas resource base was assumed to be approximately 235 trillion cubic feet in the Rocky Mountain region at the end of 1998. Of this, 108 trillion cubic feet is off limits because of development restrictions. Essentially 45 percent of the technically recoverable unconventional gas resource is deemed currently unavailable due to environmental and access constraints. Another 87 trillion cubic feet of resource is accessible but not economical to develop with today's technology and gas prices. Given these restrictions and economic realities, the current production level of 2.1 trillion cubic feet per year from unconventional sources is projected to increase to only 2.7 trillion cubic feet by 2020.

Under the conditions of the Accelerated Depletion Case, only limited improvements in technology are assumed to be made with respect to reservoir characterization and well performance, while exploration technology experiences no improvements at all. Optimization and cost reduction technologies are assumed to make some modest improvements, as in the Reference Case, and additional access is restricted under the Accelerated Depletion Case.[22]

[22]Small amounts of access were granted to those plays that had active development in 1999.

As shown in Table 6, the results of the Accelerated Depletion Case in the Rocky Mountain basins are as follows:

- Natural gas prices in the Rocky Mountain region are projected to reach $3.69 per thousand cubic feet in 2020, compared with $2.40 per thousand cubic feet in the Reference Case. Lower 48 average wellhead prices in 2020 are projected to reach $4.12 per thousand cubic feet in the Accelerated Depletion Case and $2.79 per thousand cubic feet in the Reference Case.
- 141 trillion cubic feet (38 percent) of the resource is projected to be either not accessible or economically infeasible in 2020.
- Production of natural gas is projected to remain modest, reaching 3.8 trillion cubic feet in 2020 compared with about 5 trillion cubic feet in the Reference Case.

### *Providing High Access to Rocky Mountain Basins*

One potential approach to stimulating additional natural gas production (and countering the effects of accelerated depletion) is to provide increased access to resources in the Rocky Mountain natural gas basins. A list of the basins where access is expanded in the High Rocky Mountain Access Case is given in Appendix F. In this case, access to those basins is projected to increase steadily over the course of the next 20 years. (All other response levers are consistent with those in the Accelerated Depletion Case.)

As shown in Table 7, the results of the Accelerated Depletion with High Rocky Mountain Access Case are as follows:

- Total natural gas production from Rocky Mountain basins is projected to be 0.5 trillion cubic feet higher than in the Accelerated Depletion Case, at 4.3 trillion cubic feet per year in 2020.
- Natural gas wellhead prices in the Rocky Mountain region are projected to be 30 cents per thousand cubic feet lower, at $3.39 per thousand cubic feet in 2020.
- The great bulk of the Rocky Mountain unconventional natural gas resource is projected to become accessible, leaving only 18 trillion cubic feet without access in 2020.
- About one-third of the unconventional resource made physically accessible is projected to remain uneconomical due to high costs and inadequate exploration and production technology.

**Table 6. Projected Unconventional Natural Gas Resource Base, Natural Gas Production, and Wellhead Natural Gas Prices in the Rocky Mountain Region, Accelerated Depletion Case, 2000 and 2020**

| Projection | 2000 | 2020 |
|---|---|---|
| **Unconventional Resource Base (Trillion Cubic Feet)** | | |
| Accessible and Economical | 39 | 110 |
| Accessible But Not Economical | 87 | 44 |
| Not Accessible | 108 | 97 |
| **Total Unconventional Resource** | **235** | **251** |
| Total Regional Natural Gas Production (Trillion Cubic Feet per Year) | 3.1 | 3.8 |
| Regional Natural Gas Wellhead Price (1998 Dollars per Thousand Cubic Feet) | 2.20 | 3.69 |

Source: Energy Information Administration, Office of Integrated Analysis and Forecasting, National Energy Modeling System run OGDEPL.D051200A.

**Table 7. Projected Unconventional Natural Gas Resource Base, Natural Gas Production, and Wellhead Natural Gas Prices in the Rocky Mountain Region, Accelerated Depletion and Accelerated Depletion with High Rocky Mountain Access Cases, 2000 and 2020**

| Projection | Accelerated Depletion | | Accelerated Depletion with High Access, 2020 |
|---|---|---|---|
| | 2000 | 2020 | |
| **Unconventional Resource Base (Trillion Cubic Feet)** | | | |
| Accessible and Economical | 39 | 110 | 148 |
| Accessible But Not Economical | 87 | 44 | 84 |
| Not Accessible | 108 | 97 | 18 |
| **Total Unconventional Resource** | **235** | **251** | **251** |
| Total Regional Natural Gas Production (Trillion Cubic Feet per Year) | 3.1 | 3.8 | 4.3 |
| Regional Natural Gas Wellhead Price (1998 Dollars per Thousand Cubic Feet) | 2.20 | 3.69 | 3.39 |

Source: Energy Information Administration, Office of Integrated Analysis and Forecasting, National Energy Modeling System runs OGDEPL.D051200A and OGACCESS.D051200A.

## *Providing Rapid Technological Progress to Rocky Mountain Basins*

A second alternative for increasing production and arresting the effects of accelerated depletion would be to increase the rate at which technology is developed. More rapid technology development would expand the technically recoverable resource base by increasing the productive areas of economic plays, increasing efficiency, and reducing the costs associated with the exploration and production of natural gas resources.

### Improved Productivity Technology

To evaluate gas production in the Rocky Mountains in the Accelerated Depletion with Improved Productivity Technology Case, the reservoir characterization and well performance technology levers were changed as requested by the Office of Fossil Energy, so that the rate of change in productivity technology was 50 percent higher than in the Reference Case. Other types of technology growth were kept at the reference level.

The effects of the improved productivity technology assumption on Rocky Mountain natural gas resources in the Accelerated Depletion Case (Table 8) are summarized below:

- Natural gas production from the Rocky Mountain basins in 2020 is projected to be 1.5 trillion cubic feet higher than in the Accelerated Depletion Case, at 5.3 trillion cubic feet of annual production.
- The Rocky Mountain natural gas wellhead price is projected to be $2.45 per thousand cubic feet in 2020, $1.24 per thousand cubic feet lower than in the Accelerated Depletion Case.
- The technically recoverable resource is projected to grow by 86 trillion cubic feet, yielding a total of 337 trillion cubic feet.
- Despite improvements in exploration and production technology and considerable growth in the resource, 37 percent of the resource base (126 trillion cubic feet) is projected to remain inaccessible in 2020, because of the limits imposed by environmental restrictions on exploration and production.

### Rapid Technology Growth

To examine the impacts of the Accelerated Depletion with Rapid Technology Growth Case on Rocky Mountain gas production, all technology settings—including production technology—were set roughly 50 percent higher than the Reference Case settings. Access was still

**Table 8. Projected Unconventional Natural Gas Resource Base, Natural Gas Production, and Wellhead Natural Gas Prices in the Rocky Mountain Region, Accelerated Depletion and Accelerated Depletion with Improved Productivity Technology Cases, 2000 and 2020**

| Projection | Accelerated Depletion | | Accelerated Depletion with Improved Productivity Technology, 2020 |
|---|---|---|---|
| | 2000 | 2020 | |
| **Unconventional Resource Base (Trillion Cubic Feet)** | | | |
| Accessible and Economical | 39 | 110 | 158 |
| Accessible But Not Economical | 87 | 44 | 53 |
| Not Accessible | 108 | 97 | 126 |
| **Total Unconventional Resource** | **235** | **251** | **337** |
| Total Regional Natural Gas Production (Trillion Cubic Feet per Year) | 3.1 | 3.8 | 5.3 |
| Regional Natural Gas Wellhead Price (1998 Dollars per Thousand Cubic Feet) | 2.20 | 3.69 | 2.45 |

Source: Energy Information Administration, Office of Integrated Analysis and Forecasting, National Energy Modeling System runs OGDEPL.D051200A and OGFRHTEC.D051200A.

**Table 9. Projected Unconventional Natural Gas Resource Base, Natural Gas Production, and Wellhead Natural Gas Prices in the Rocky Mountain Region, Accelerated Depletion and Accelerated Depletion with Rapid Technology Cases, 2000 and 2020**

| Projection | Accelerated Depletion | | Accelerated Depletion with Rapid Technology, 2020 |
|---|---|---|---|
| | 2000 | 2020 | |
| **Unconventional Resource Base (Trillion Cubic Feet)** | | | |
| Accessible and Economical | 39 | 110 | 210 |
| Accessible But Not Economical | 87 | 44 | 44 |
| Not Accessible | 108 | 97 | 140 |
| **Total Unconventional Resource** | **235** | **251** | **394** |
| Total Regional Natural Gas Production (Trillion Cubic Feet per Year) | 3.1 | 3.8 | 6.5 |
| Regional Natural Gas Wellhead Price (1998 Dollars per Thousand Cubic Feet) | 2.20 | 3.69 | 1.86 |

Source: Energy Information Administration, Office of Integrated Analysis and Forecasting, National Energy Modeling System runs OGDEPL.D051200A and OGRTECH.D051200A.

assumed to be restricted, keeping this setting consistent with the Accelerated Depletion Case.

The effects of the rapid technology assumption on Rocky Mountain natural gas resources in the Accelerated Depletion Case (Table 9) are summarized below:

- Natural gas production in the Rocky Mountain region is projected to be 6.5 trillion cubic feet in 2020, exceeding the projected production in the Accelerated Depletion Case by 2.7 trillion cubic feet.
- Natural gas wellhead prices in the Rocky Mountain region in 2020 are projected to be $1.86 per thousand cubic feet, about half their level in the Accelerated Depletion Case.
- The technically recoverable resource is expected to be 143 trillion cubic feet higher than in the Accelerated Depletion Case; however, 140 trillion cubic feet of the resource base is projected to remain inaccessible in 2020, with an additional 44 trillion cubic feet being accessible but not economically viable.

## *Providing High Access and Accelerated Technological Progress to Rocky Mountain Basins*

The Accelerated Depletion with High Rocky Mountain Access and Improved Productivity Technology Case and the Accelerated Depletion with High Rocky Mountain Access and Rapid Technology Case combine high resource access and more rapid technological progress assumptions. The effects on Rocky Mountain gas production and prices (Tables 10 and 11) are summarized below.

### Accelerated Depletion with High Rocky Mountain Access and Improved Productivity Technology

- In this analysis case, natural gas production in the Rocky Mountains is projected to be 5.7 trillion cubic feet in 2020, 1.9 trillion cubic feet higher than the level projected in the Accelerated Depletion Case.
- Natural gas wellhead prices in the Rocky Mountain region are projected to be $2.25 per thousand cubic

**Table 10. Projected Unconventional Natural Gas Resource Base, Natural Gas Production, and Wellhead Natural Gas Prices in the Rocky Mountain Region, Accelerated Depletion and Accelerated Depletion with High Rocky Mountain Access and Improved Productivity Technology Cases, 2000 and 2020**

| Projection | Accelerated Depletion | | Accelerated Depletion with High Access and Improved Productivity Technology, 2020 |
|---|---|---|---|
| | 2000 | 2020 | |
| **Unconventional Resource Base (Trillion Cubic Feet)** | | | |
| Accessible and Economical | 39 | 110 | 215 |
| Accessible But Not Economical | 87 | 44 | 95 |
| Not Accessible | 108 | 97 | 23 |
| **Total Unconventional Resource** | **235** | **251** | **333** |
| Total Regional Natural Gas Production (Trillion Cubic Feet per Year) | 3.1 | 3.8 | 5.7 |
| Regional Natural Gas Wellhead Price (1998 Dollars per Thousand Cubic Feet) | 2.20 | 3.69 | 2.25 |

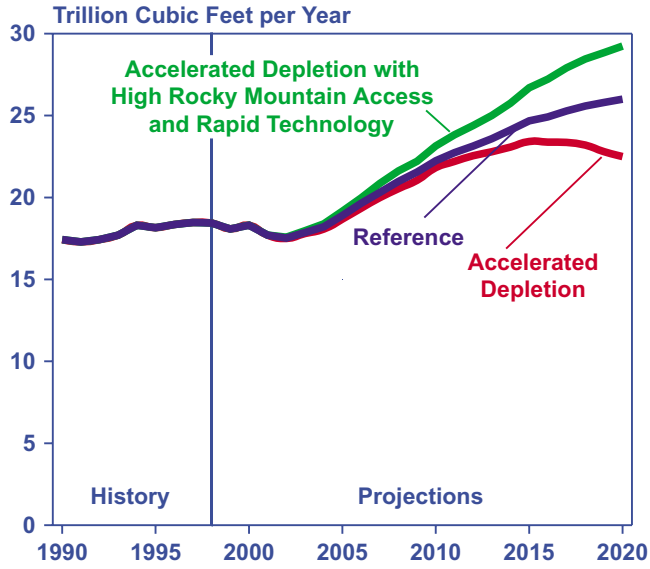
Source: Energy Information Administration, Office of Integrated Analysis and Forecasting, National Energy Modeling System runs OGDEPL.D051200A and OGACCFR.D051200A.

**Table 11. Projected Unconventional Natural Gas Resource Base, Natural Gas Production, and Wellhead Natural Gas Prices in the Rocky Mountain Region, Accelerated Depletion and Accelerated Depletion with High Rocky Mountain Access and Rapid Technology Cases, 2000 and 2020**

| Projection | Accelerated Depletion | | Accelerated Depletion with High Access and Rapid Technology, 2020 |
|---|---|---|---|
| | 2000 | 2020 | |
| **Unconventional Resource Base (Trillion Cubic Feet)** | | | |
| Accessible and Economical | 39 | 110 | 286 |
| Accessible But Not Economical | 87 | 44 | 79 |
| Not Accessible | 108 | 97 | 27 |
| **Total Unconventional Resource** | **235** | **251** | **393** |
| Total Regional Natural Gas Production (Trillion Cubic Feet per Year) | 3.1 | 3.8 | 7.6 |
| Regional Natural Gas Wellhead Price (1998 Dollars per Thousand Cubic Feet) | 2.20 | 3.69 | 1.69 |

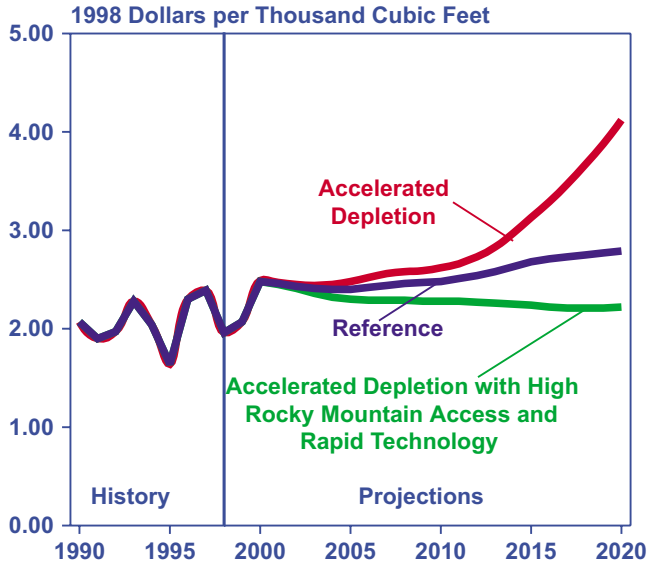
Source: Energy Information Administration, Office of Integrated Analysis and Forecasting, National Energy Modeling System runs OGDEPL.D051200A and OGRAPID.D051200A.

**Figure 15. Lower 48 Natural Gas Production in the Reference, Accelerated Depletion, and Accelerated Depletion with High Rocky Mountain Access and Rapid Technology Cases, 1990-2020**




Source: Energy Information Administration, Office of Integrated Analysis and Forecasting, National Energy Modeling System runs OGBASE.D051200A, OGDEPL.D051200A, and OGRAPID.D051200A.

**Figure 16. Lower 48 Natural Gas Wellhead Prices in the Reference, Accelerated Depletion, and Accelerated Depletion with High Rocky Mountain Access and Rapid Technology Cases, 1990-2020**




Source: Energy Information Administration, Office of Integrated Analysis and Forecasting, National Energy Modeling System runs OGBASE.D051200A, OGDEPL.D051200A, and OGRAPID.D051200A.

feet in 2020, $1.44 per thousand cubic feet lower than in the Accelerated Depletion Case.

- In 2020, 64 percent of the technically recoverable resource is expected to be economical and accessible, leaving only 7 percent of the resource "off limits."

### Accelerated Depletion with High Rocky Mountain Access and Rapid Technology

- In this case, natural gas production in the Rocky Mountain region is projected to be twice as large as it is in the Accelerated Depletion Case, reaching 7.6 trillion cubic feet of annual production in 2020, as more resources are open to development and more rapid introduction of technology lowers production costs. Lower 48 gas production is projected to total 29.2 trillion cubic feet in 2020, compared with only 22.5 trillion cubic feet in the Accelerated Depletion Case and 26.0 trillion cubic feet in the Reference Case (Figure 15).
- With higher production levels increasing supply, lower 48 natural gas prices are projected to be $2.22 per thousand cubic feet in 2020—$0.57 lower than in the Reference Case and $1.90 lower than in the Accelerated Depletion Case (Figure 16).
- The technically recoverable resource base in 2020 is projected to be 142 trillion cubic feet higher than in the Accelerated Depletion Case (Table 11), with only 7 percent remaining "off limits."

As expected, the combination of high access to Rocky Mountain resources and more rapid technological progress leads to the highest projections of gas production and the lowest projected wellhead costs for natural gas. Under these conditions the resource base is expected to grow significantly, and the large majority of it becomes accessible and economical. The results of the two cases assuming more rapid technological progress suggest that the effects of accelerated depletion could be offset to some degree by increased access to natural gas reserves in the Rocky Mountains in combination with improvements in exploration and production technology.

## Conclusion

This study has shown that projections of future oil and gas prices and production are influenced by the assumptions that are made about the effects of depletion. The NEMS OGSM incorporates the effects of depletion in its projections. In the Accelerated Depletion Case, the change in assumptions about the effects of depletion causes the projected production of lower 48 natural gas in 2020 to be 3.5 trillion cubic feet , or 13 percent, lower than in the Reference Case, with wellhead gas prices projected to be $1.33 per thousand cubic feet, or 48 percent, higher.

Changes in assumptions about world oil prices, the availability of natural gas imports, and the rate of

technological innovation modify the projected effects of accelerated depletion on prices and production. Higher projections of natural gas imports partially offset the higher prices projected in the Accelerated Depletion Case, but domestic gas production is also reduced. Assuming a higher path for world oil prices does not return natural gas production in the Accelerated Depletion Case to its level in the Reference Case but does cause projected oil production to be higher. Assuming a faster rate of technological innovation partially offsets the effects of accelerated depletion.

When increased access to Rocky Mountain natural gas resources is assumed, projected natural gas production is increased. Combining the increased access and improved technological progress assumptions raises the projected production levels for natural gas above those in the Reference Case. The projected real wellhead price of lower 48 natural gas in the Accelerated Depletion with High Rocky Mountain Access and Rapid Technology Case is less than half the projected price in the Accelerated Depletion Case. These results suggest that at least in the short to medium term, the potential negative effects of accelerated depletion could be offset to some degree by more research and by expanding the areas where exploration and production is allowed.

The assumptions used to create the Reference Case specifically extrapolate from historical trends, whereas the assumptions used in the Accelerated Depletion Case were chosen to illustrate a scenario in which the effects of depletion are more acute then they have been historically. Therefore, the Accelerated Depletion Cases, which illustrate how the effects of depletion may become increasingly important in the decades to come, should be seen as sensitivity cases rather than forecasts.